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do hereby verify that I am fully conversant with the Japanese and English languages and that attached translation signed by me is, to the best of my knowledge and belief, a true and correct English translation of the Japanese Patent Application No. 2002-91034.

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[TITLE OF THE INVENTION] HONEYCOMB FORMING DIE
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[TITLE OF THE INVENTION] HONEYCOMB FORMING DIE

[Scope of the Claim for Patent]

[Claim 1] A die for forming a honeycomb body, the
5 die comprising a structure provided with:

 groovy slits formed on a front face thereof, the
slits being formed by cell blocks; and

 back holes on a back face thereof, each hole being
communicatively connected with the slit,

10 characterized in that the number of the cell blocks
per one side of the die is an even number.

[Claim 2] A die for forming a honeycomb body
according to claim 1, wherein curved portions are formed at
four corners on an peripheral portion of the die, and a
15 radius of curvature of the curved portions is 0.5 to 1.5 mm.

[Claim 3] A die for forming a honeycomb body
according to claim 1 or 2, wherein the die is made of hard
metal having high abrasion resistance.

[Claim 4] A die for forming a honeycomb body
20 according to claim 3, wherein the hard metal is formed by
compacting, followed by sintering, at high temperature, a
hard metal carbide compound powder of transition metal
element series with an iron group metal binder having
tenacity.

25 [Claim 5] A die for forming a honeycomb body
according to any of claims 1 to 4, wherein the back holes
are disposed at every other position of the cell blocks.

[Claim 6] A die for forming a honeycomb body according to any of claims 1 to 5, wherein a thickness of the die is 15 to 30 μm .

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a die for forming a
5 honeycomb body.

[0002]

[Prior Art]

A honeycomb structure has mainly been used in a
filter for trapping particulate matter in exhaust gas from
10 an internal combustion engine, boiler, and the like,
particularly diesel particulate matter or as a catalyst
carrier for purifying exhaust gas.

[0003] Heretofore, as an extrusion die for a ceramic
honeycomb body, for example, there has been known the
15 extrusion die (10) for a honeycomb body shown in Figs. 4
and 5, which is provided with groovy slits (2) on the front
face of a base material made of stainless steel and iron,
the groovy slits being formed by cell blocks, and provided
with back holes (4), on a back face thereof, each
20 communicatively connected with the slit (2).

[0004] At the time, when a honeycomb segment is
extruded using, for example, a die having a square
honeycomb structure (in particular, when a honeycomb
segment whose outer wall thickness is not large is
25 extruded), if the number of cell blocks per one side is an
odd number, design of cell blocks 3 and back holes 4 is not
appropriate particularly at corner portions 7. Accordingly,

when the honeycomb segment is extruded by a die jig shown in Fig. 6, a clay extrusion speed is made uneven at slits, from which strain is generated on an extruded face (pattern) of an extruded body and the formed body is bent.

5 [0005] Further, when the cell blocks 3 are formed at right angle at the corner portions 7 as shown in Fig. 2, flow of clay is deteriorated. Accordingly, concavo-convex portions may be formed on an extruded face, and fine splits 40 may be generated on an outer wall in a resultant
10 extruded body (honeycomb structure) as shown in Fig. 7(b).

[0006]

[Problems to be solved by the Invention]

The present invention is made in view of the above described problems heretofore, and aims to provide an
15 extrusion die for a honeycomb body, which is capable of inhibiting strain generated on an extruded face of an extruded body after extrusion and bending of honeycomb structure, and maintaining a stable frictional force of extrusion, and which is excellent in extrusion-moldability
20 and abrasion resistance.

[0007]

[Means to solve the Problem]

That is, according to the present invention, there is provided a die for forming a honeycomb body, the die
25 comprising a structure provided with: groovy slits formed on a front face thereof, the slits being formed by cell blocks; and provided with back holes on a back face thereof,

each hole being communicatively connected with the slit, characterized in that the number of the cell blocks per one side of the die is an even number.

At the time, it is preferable in the present invention that curved portions be formed at four corners on an peripheral portion of the die and that a radius of curvature of the curved portions be 0.5 to 1.5 mm.

[0008] Further, in the present invention, it is preferable that a die be made of hard metal having high abrasion resistance and that the hard metal be formed by compacting, followed by sintering at high temperature, a hard metal carbide compound powder of transition metal element series with an iron group metal binder having tenacity.

[0009] At the time, it is preferable that the back holes are disposed at every other position of the cell blocks and that a thickness of the die is 15 to 30 mm.

[0010]

[Mode for carrying out the Invention]

Detailed description will be made below on embodiments of the present invention on the basis of the drawings.

Fig. 1 is an example of a corner portion of an extruded face formed by a die and a holding plate of the present invention and a front perspective view showing an example of a layout of cell blocks and back holes.

At the time, a main feature of the die of the present

invention (which is designed to provide, for example, one back hole 4 for every four cell blocks) resides in that the number N of cell blocks per one side of the die is set to an even number (refer to Fig. 4).

5 [0011] With the above arrangement, when extrusion is executed using a die having a square honeycomb structure (in particular, when a honeycomb segment whose outer wall thickness is not large is extruded), the cell blocks 3 and the back holes 4 at the corner portions 7 can be uniformly
10 designed at four upper, lower, right, and left corners as shown in Fig. 1. Accordingly, an extruding speed of clay in slits 9 formed by a holding plate 12 and the corner portions 7 and an extruding speed thereof in slits 2 formed in the die can be made uniform, which can prevent
15 distortion generated on an extruded face (pattern) of an extruded body and bending of the formed body.

[0012] Further, as shown in Fig. 1, it is preferable that the die of the present invention have curved portions 8 at four corners of a peripheral portion of the die and
20 that the curved portions 8 have a radius of curvature r of 0.5 to 1.5 mm.

With the above arrangement, when extrusion is executed using the die having the square honeycomb structure (in particular, when the honeycomb segment whose
25 outer wall thickness is not large is extruded), a formed body having an excellent extruded face and an excellently attached outer wall can be obtained as shown in Fig. 7(a)

without uneven portions on the extruded face and without generation of fine splits 40 on the outer wall (refer to Fig. 7(b)).

[0013] Further, the die of the present invention is preferably made of hard metal having high abrasion resistance.

With the above arrangement, even if a raw material containing a material having very high hardness such as SiC and the like is extruded, the abrasion resistance (life) of the the die can be enhanced as well as a defect in shape of the die due to abrasion thereof can be overcome.

[0014] Although there is no particular restriction as to the hard metal, it is preferably formed by compacting, followed by sintering, at high temperature, a hard metal carbide compound powder of transition metal element series, for example, WC, TiC, TaC, etc., with an iron group metal binder having high tenacity such as Co and Ni, etc.

[0015] Further, the die of the present invention preferably has a thickness (t) of 15 to 30 mm (more preferably 15 to 24 mm) (refer to Fig. 4).

The thickness of the die was determined in consideration of strength of the die and flow of clay when a honeycomb body is extruded.

At the time, when the die is excessively thick, it is improper because not only accuracy of the back holes machined by a drill and the like is deteriorated but also strain due to contraction in final sintering is increased.

In contrast, when the die is excessively thin, it is broken when a honeycomb structure is extruded by the die due to its insufficient strength.

Note that when the honeycomb structure is formed,
5 clay can stably flow in the die by making a back hole portion as short as possible because a flow resistance in length is reduced thereby.

[0016] Further, in the present invention, when hard metal is used as a material of the die, it is preferable to
10 dispose a back hole at every other positions of the cell blocks because the cell blocks are liable to be broken when a connecting area of the back holes and the cell blocks is excessively small.

[0017]

15 [EXAMPLES]

The present invention will further be described hereinafter in detail based on examples, but the present invention is not limited to these examples.

(Method of production of hard metal die: used in examples 1
20 to 3, comparative examples 1 to 4)

After WC-Co (composite body of tungsten carbide and cobalt) powder as hard metal was formed into a square plate of 100 mm on a side and 40 mm in thickness (100 × 100 × 40 t) by press work and the like, it was calcined at 500 to
25 700°C. Thereafter, back holes having a predetermined diameter and a predetermined depth were drilled with a predetermined pitch from one end face of the square plate,

and then the square plate was subjected to final sintering at 1000 to 1300°C, thereby it was contracted up to a square plate of 24 mm in thickness and 70 mm on a side (70 × 70 × 24 t). Thereafter, predetermined dimensions of the square plate was accurately obtained by polishing the entire surface thereof.

Next, a hard metal die whose slit width and die shape were formed square was obtained by forming slits on the other face of the thus obtained square plate in a lattice pattern at every other positions of the back holes, which were previously formed on one face of the square plate, by wire cut electric-discharge machining, or creep feed grinding or plunge cut grinding with a grinding stone containing a diamond abrasive grain.

[0018]

(Extrusion of the honeycomb body)

The die for forming a honeycomb body was set to a die jig shown in Fig. 6, and a honeycomb structure was extruded using clay composed of raw material of argillaceous Si-SiC.

Note that the clay was obtained by kneading a raw material made of metal silicon (Me-Si) and SiC which were prepared at a ratio of 25:75 and to which water, an organic binder, and a hole forming material were added.

[0019]

(Example 1, Comparative Examples 1 and 2)

Honeycomb structures were extruded, respectively using hard metal dies shown in Table 1 (example 1,

comparative examples 1 to 2). The results are shown in Table 1.

[0020]

[Table 1]

	Type of die			Shape of extruded face of honeycomb structure	Evaluation
	Number of cell blocks per one side	Back hole area ratio of respective corner portions *	Disposition of back holes		
Example 1	Even number (Refer to Fig. 1)	Same in respective corner portions	Every other positions	○	○
Comparative example 1	Odd number (Refer to Fig. 2)	Area difference of about 15 % in diagonal line direction	Every other positions	×	×
				(Concavo-convex portions occurring according to difference of area)	(Deformation due to difference in area)
Comparative example 2	Even number (Refer to Fig. 3)	Same in respective corner portions	All holes	○	×
					(Breakage of die due to insufficient strength)

*1 Corner portions: Dotted-line portions in Figs. 1 to 3

[0021] From the results of Table 1, when the number of the cell blocks per one side of the die was even number and the back holes were disposed at every other positions of the cell blocks in the back hole structure of the die as shown in Fig. 1 (example 1), back hole area ratios could be set to the same ratio in respective corner portions.

Accordingly, strain generated on an extruded face (pattern) of a honeycomb structure after extrusion and bending of an extruded body could be prevented.

In contrast, when the number of the cell blocks per one side of the die was odd number and the back holes were disposed at every other positions of the cell blocks in the back hole structure of the die as shown in Fig. 2

(comparative example 1), back hole area ratios had an area difference of about 15% in a diagonal line direction at respective corner portions. Accordingly, strain generated on an extruded face (pattern) of a honeycomb structure after extrusion and bending of an extruded body were generated.

Further, when the number of the cell blocks per one side of the die was even number and all the holes were made to back holes with respect to the cell blocks in the back hole structure of the die as shown in Fig. 3 (comparative example 2), back hole area ratios could be set to the same ratio at respective corner portions. Accordingly, strain, which was generated on an extruded face (pattern) of a honeycomb structure after extrusion, and bending of a

formed body could be prevented. However, the die was broken because its strength was insufficient.

[0022]

(Examples 2 and 3, Comparative Examples 3 and 4)

5 Honeycomb structures were extruded, respectively
using hard metal dies shown in Fig.1 having curved portions
8 shown in Table 2, the curved portions 8 being formed to
corner portions 7 of cell blocks 3 on an outermost
peripheral portion of the die. The results are shown in
10 Table 2.

[0023]

[Table 2]

	Radius of curvature r of curved portion (mm) [refer to Fig. 1]	Presence or absence of crack of extruded honeycomb structure
Example 2	0.5	Absent
Example 3	1.5	Absent
Comparative example 3	0.0	Present
Comparative example 4	2.0	Breakage of cell blocks

[0024] From the results of Table 2, the present invention could prevent occurrence of cracks at the corner portions 7 of a honeycomb structure after extrusion by setting a radius of curvature r of a curved portion 8 to 0.5 to 1.5 mm with respect to a length of a side of a cell block (examples 2 to 3).

In contrast, in a comparative example 3, cracks were generated at corner portions 7 of a honeycomb structure after extrusion. This is because that the comparative example 3 had no curved portions 8, and thus a small amount of clay flew from back holes of the corner portions 7.

Further, in a comparative example 4, when a honeycomb structure was extruded, cell blocks were broken. This is because that a radius of curvature r of curved portions 8 exceeded 1.5 mm, and thus a die had an insufficient strength.

[0025]

(Examples 4 and 5, Comparative Examples 5 and 6)

After WC-Co (composite body of tungsten carbide and cobalt) powder as hard metal was formed into a square plate of 100 mm on a side and 40 mm in thickness (100 × 100 × 40 t), it was tentatively sintered at 500 to 700°C. Thereafter, back holes having a predetermined diameter and a predetermined depth were drilled with a predetermined pitch from one end face of the square plate, and then the square plate was subjected to final sintering at 1000 to 1300°C, thereby it was contracted up to a square plate of

24 mm in thickness and 70 mm on a side (70 × 70 × 24 t).
Thereafter, a predetermined dimension of the square plate
was accurately obtained by polishing the entire surface
thereof.

5 Next, a hard metal die whose slit width and die shape
were formed in a square shape was obtained by forming slits
on the other end surface of the thus obtained square plate
in a lattice pattern at every other positions of the back
holes, which were previously formed on one face of the
10 square plate, by wire cut electric discharge machining, or
creep feed grinding or plunge cut grinding with a grinding
stone containing a diamond abrasive grain.

 Next, honeycomb structures were extruded,
respectively using the thus obtained dies. The results are
15 shown in Table 3.

[0026]

[Table 3]

	Thickness of die (mm)	Shape of product	Amount of bending (mm)*	Crack of die	Evaluation
Example 4	15	○	0.5	Absent	○
Example 5	30	○	0.6	Absent	○
Comparative example 5	10	○	0.3	Breakage of die	×
Comparative example 6	40	×	1.2	Absent	×

* Amount of bending: a stroke of a gauge, which was shown by a dial gauge located at the center of a segment was measured with respect to the two points at the opposite ends of the segment.

[0027] From the results of Table 3, it was confirmed that a thickness (t) of the die (refer to Fig. 4) was preferably set to 15 to 30 mm as a result that strength of the die, and a flow rate of clay in extrusion of a formed body were optimized. (Comparative example 4 to 5)

At the time, a die whose thickness was excessively large as in the comparative example 6 was improper because not only an accuracy of the back holes machined by a drill and the like was deteriorated but also strain due to contraction in final sintering was increased.

In contrast, when a thickness of the die was excessively small as in the comparative example 5, the die was broken due to insufficient strength of the die when a honeycomb structure was extruded.

- 15 [0028]

[Effect of the Invention]

As described above, the die for forming a honeycomb body of the present invention is possible to reduce strain generated on an extruded face of the honeycomb body after extrusion, possible to maintain a stable frictional force of extrusion, excellent in extrudability, and excellent in abrasion resistance.

[Brief Description of the Drawings]

25 Fig. 1 is a front perspective view showing an example of a corner portion of an extruded face formed by a die and a holding plate of the present invention and shows an

example of a layout of cell blocks and back holes.

Fig. 2 is a front perspective view showing an example of a layout of cell blocks and back holes at a corner portion of an extruded face formed by a conventional die and a conventional holding plate.

Fig. 3 is a front perspective view showing another example of the layout of the cell blocks and the back holes at the corner portion of the extruded face formed by the conventional die and the conventional holding plate.

Fig. 4 is a schematic sectional view showing an example of a die for forming a honeycomb body.

Fig. 5 is an explanatory view showing a relation between cell blocks and back holes.

Fig. 6 is a configurational view showing an example of a die jig for forming a honeycomb body.

Figs. 7(a) and 7(b) show a shape of an extruded honeycomb structure, in which Fig. 7(a) shows a case in which the die of Fig. 1 is used, and Fig. 7(b) shows a case in which the die of Fig. 2 is used.

[Explanation of Symbols]

1...die for forming a honeycomb body, 2...slit, 3...cell block, 4...back hole, 6...diaphragm portion, 7...corner portion, 8...curved portion, 10...die for extruding a honeycomb body, 12...holding plate, 14...back holding plate, 15...holding jig, 16...forming ring holder, 18...forming ring, 20...die holder, 22...noodle die, 24...screen, 30...honeycomb structure, 40...fine

split.

[NAME OF DOCUMENT] ABSTRACT

[ABSTRACT]

[Theme] There is provided a die for forming the
honeycomb body, strain generated on an extruded face of the
5 honeycomb body after extrusion and bending of the honeycomb
body can be reduced as well as the die can maintain a
stable frictional force of extrusion and is excellent in
extrusion-moldability and abrasion resistance.

[Means]

10 Disclosed is a die 10 for forming a honeycomb body
having a structure provided with groovy slits 2 on a front
face thereof, the slits being formed by cell blocks 3 and
back holes 4 on a back surface thereof, each hole being
communicatively connected with the slit. The number N of
15 the cell blocks per one side of the die is an even number.

[Adopted Figure] Fig. 4



FIG. 1

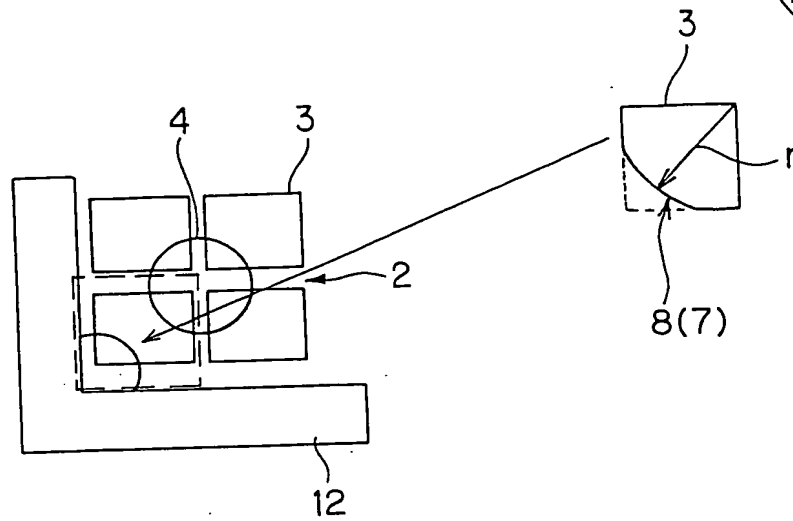


FIG. 2

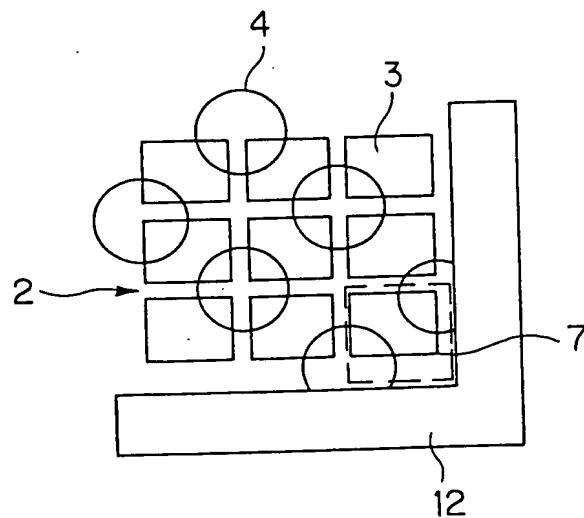


FIG. 3

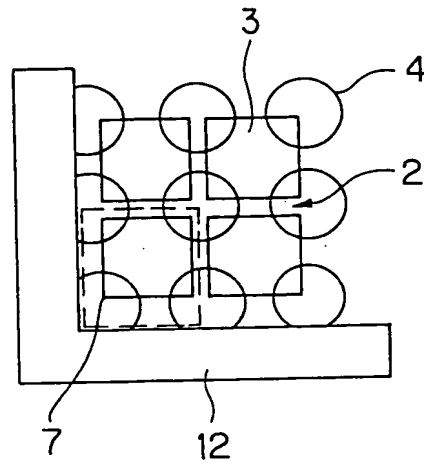


FIG. 4

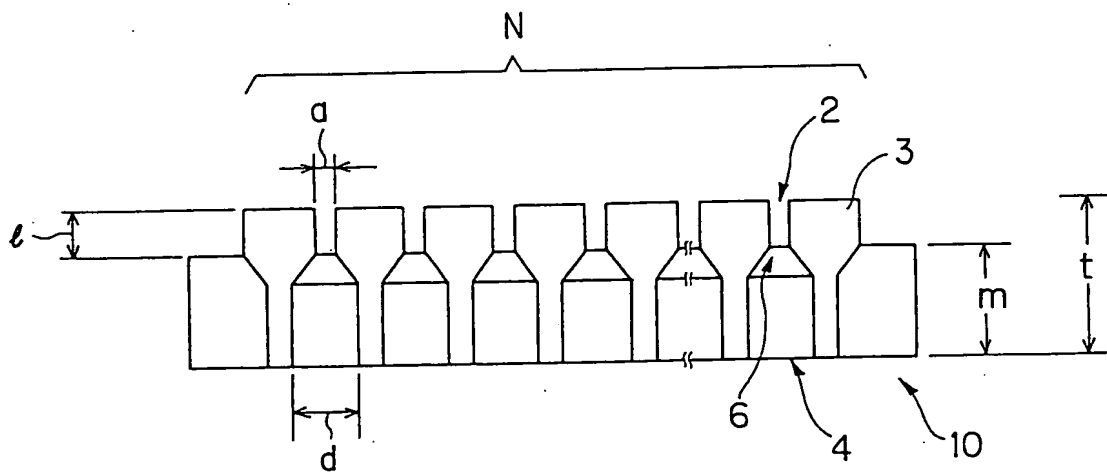


FIG. 5

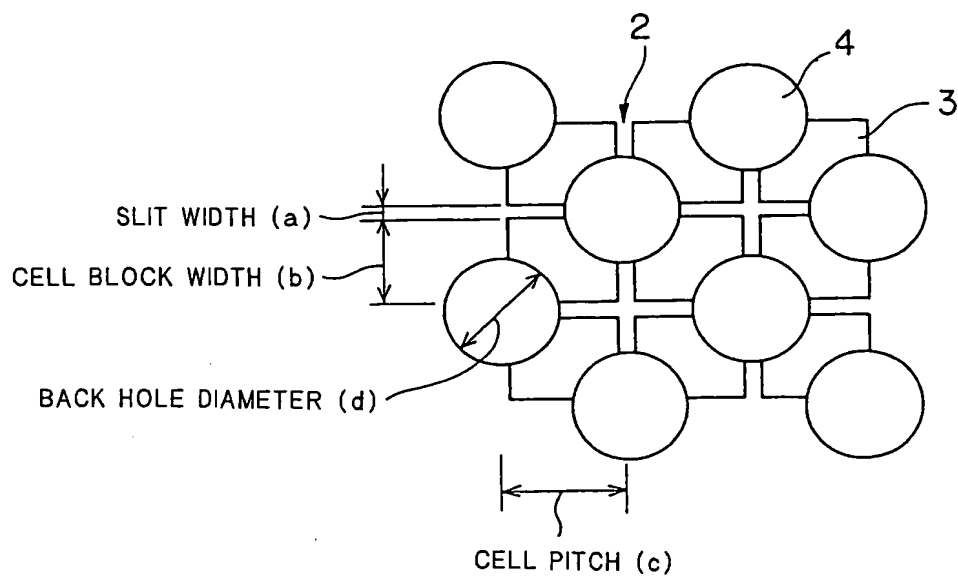


FIG. 6

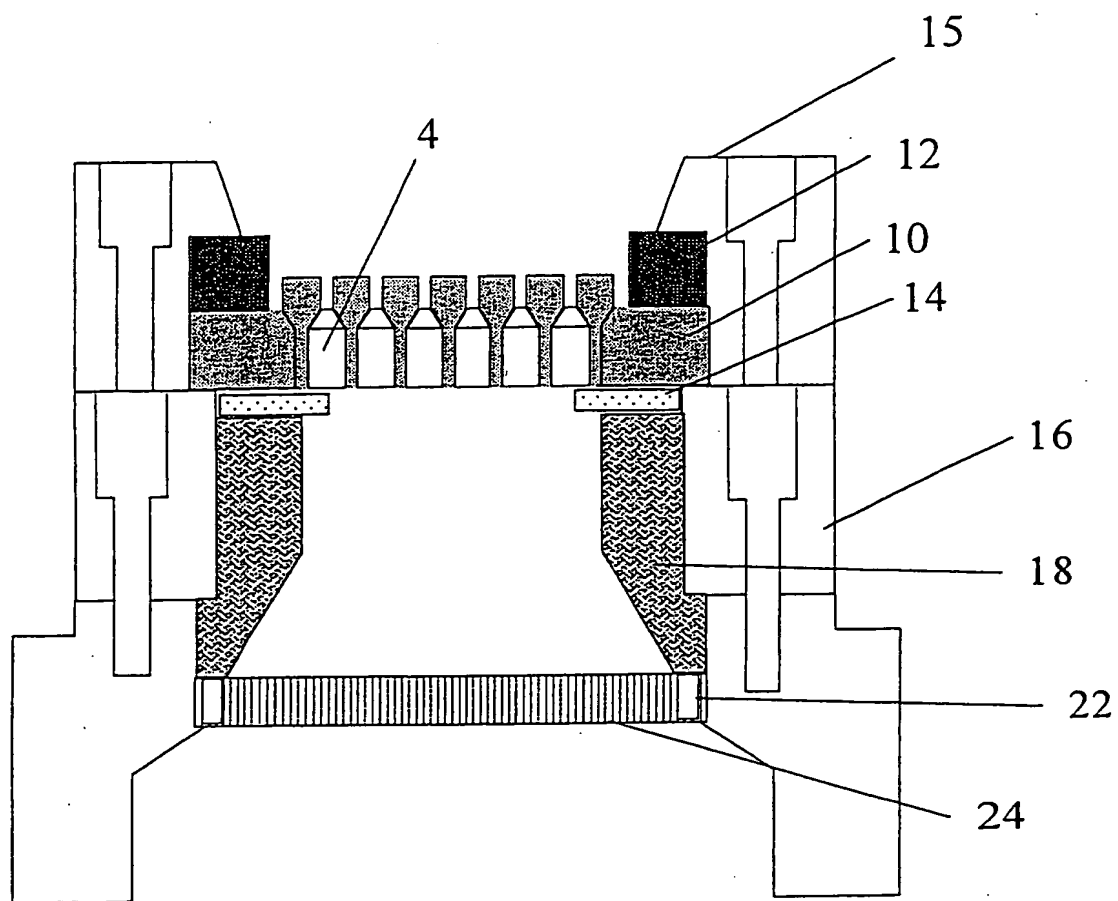


FIG. 7(a)

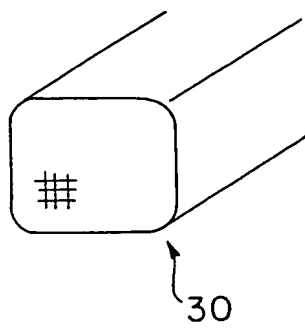


FIG. 7(b)

